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DREDGING PENNSYLVANIA ANTHRACITE[1/]

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FOREWORD

The river- or dredge-coal industry of Pennsylvania is conducted on many of the rivers and creeks that drain the Pennsylvania anthracite fields. Coal thus recovered found its way into the streams as coal was being prepared for market by the anthracite industry proper, in the northeastern part of the State. The principal rivers draining the fields, those where dredging is taking place, are the Susquehanna, Schuylkill, and Lehigh. Several creeks - the Shamokin, Mahanoy, Wiconisco, and Swatara - also are productive sources of river or creek coal. Operations along the streams cover a wide territory, and along the Susquehanna alone dredges are recovering coal for about 160 miles.

Anthracite was a significant factor in the early industrial development of the United States. Industry used it to generate steam, and railroads used it as fuel for locomotives; but it probably was most important industrially in the smelting of iron ore. For more than a hundred years homes have been heated with this fuel. From the beginning of mining in 1807, to 1940, more than 4 billion net tons of anthracite had been prepared and shipped to market. In the preparation process much of the smaller-size coal and refuse found their way into rivers and creeks which carried the material many miles. This study is concerned with the recovery of that anthracite from those rivers and creeks.

INTRODUCTION

The rivers and creeks that traverse the anthracite fields of Pennsylvania have been dredged for "river" or "dredge" coal since about 1890. The terms "river" and "dredge" apply to coal taken from the bed of such streams. The coal was not always in those streams but was deposited there as a result of mining and preparing anthracite for market in the areas they drain.

Early in the history of the Pennsylvania anthracite industry the small sizes of coal were not used as extensively as they are today. Grate, egg, stove, and chestnut were the principal sizes shipped to market and used by the local trade. Pea and smaller sizes were not considered to have any great value and generally were discarded on culm banks with other refuse from cleaning, or they were washed into the rivers and creeks coursing through the anthracite fields. Later, when it was known that the small sizes had economic value, the material in the culm banks was reworked to obtain the usable coal, and in the process additional large quantities of the smallest coal were washed into the streams. Then, too, over a period of years large quantities of the material contained in unworked culm banks were washed into the rivers and creeks by rainstorms, adding to the volume of river coal. In

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recent years, with modern preparation methods and increasing demand for small sizes, the anthracite industry has recovered virtually all coal larger than Barley (3/16- by 3/32-inch) and a good percentage of still smaller sizes. Consequently, not nearly as much coal is deposited in the streams today as in the early days of the industry.

As stated, river coal was first dredged in the 1890's, but the earliest production reports received by the Geological Survey were for 1909. From 1909 to 1940, inclusive, dredge operators reported to the Geological Survey, and subsequently to the Bureau of Mines, 17,624,533 net tons recovered. Although this is only a small fraction of the total output of anthracite it is important from the standpoint of conservation of natural resources. In 1940 this source supplied 942,944 tons of anthracite valued at $1,096,926.

The industry is unique in that comparatively little capital or labor is necessary as compared with the development work, expensive breakers, hoisting equipment, and underground haulage required by shaft mines. No tunnels, slopes, or props are needed, and little or no "dead" work is done. Equipment used in obtaining dredge or river coal is virtually limited to power suction pumps and clamshell buckets. Even less capital and labor are required than in strip or surface mining, but the product is limited to the low-priced smaller or steam sizes of anthracite.

Although this study concerns the river coal industry it seems advisable to describe the Pennsylvania anthracite fields briefly and to give a short history of that industry with special reference to early methods of preparation and disposal of the smaller or unmarketable sizes.

PENNSYLVANIA ANTHRACITE INDUSTRY

Description of Fields

The anthracite deposits of northeastern Pennsylvania are divided geologically into four fields - the Northern, Eastern Middle, Western Middle, and Southern. The total area of the four fields is about 484 square miles, of which the Northern covers 176 square miles, the Eastern Middle, 33, the Western Middle 94, and the Southern 181.

The fields are separate and distinct but are adjacent to each other, and all have their greatest length in a northeast-southwest direction. The usual shape and structure of all the fields are like a series of long, irregular basins or troughs. The surrounding mountains ordinarily are steep and rugged, and the coal pitches sharply from the sides to the valleys below. The fields lie within Carbon, Columbia, Dauphin, Lebanon, Lackawanna, Luzerne, Northumberland, Schuylkill, Susquehanna, and Wayne Counties.

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The Northern field is about 55 miles long and extends from Forest City in the northeast to Shickshinny in the southwest. Its beds are comparatively flat, except near the outcrop, and have their greatest breadth, about 6 miles, near Wilkes-Barre. The Susquehanna River and its tributaries drain the entire field.

The Eastern Middle field, which centers at Hazleton, Pa., consists of a series of canoe-shaped basins. In some of these the coal beds pitch and in others they are comparatively flat. This field has the smallest area of any and is drained principally by creeks tributary to the Susquehanna and Lehigh Rivers.

The Southern field is the largest of the four and extends virtually from Mauch Chunk, on the Lehigh River, to Dauphin, on the Susquehanna River. The beds of coal pitch steeply and at one time were subject to great pressure. The Schuylkill River and tributaries of the Susquehanna and Lehigh Rivers drain this field. Pottsville and Tamaqua are the principal cities in the Southern field.

The Western Middle field lies between the Southern field and the Susquehanna River. The Shamokin and Mahanoy Creeks are the principal watercourses; these flow into the Susquehanna near Sunbury and Herndon, respectively. The principal cities of the Western Middle field are Shamokin, Shenandoah, Mount Carmel, and Mahanoy City.

Production by Fields

The total output of anthracite in 1940 was 51,484,640 net tons. The Northern field has led in production for many years; as far back as 1885 it supplied 50 percent of the total tonnage produced, the Western Middle field ranked second, with 24 percent, and the Eastern Middle and the Southern supplied 16 and 10 percent, respectively. In 1940 the Northern field produced 53 percent of the total output of anthracite, the Western Middle 22 percent, the Southern field 15 percent, and the Eastern Middle 10 percent. For historical comparison, the tonnage of the small Bernice Basin in Sullivan County is often included in statistics of the Northern field, although the coal is classified officially as semianthracite. (In 1940 Sullivan County output amounted to 50,844 net tons.)

From the production record it is evident that the Northern and the Western Middle fields yield about 75 percent of the total output of anthracite; and the Susquehanna River, draining the former, and the Shamokin and Mahanoy Creeks, draining the latter, yield the greatest tonnage of river coal.

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Brief History of Anthracite Industry

History relates that gunsmiths used coal from the anthracite region as early as 1755, and that in 1769 one Abadiah Gore, a blacksmith of Wilkes-Barre, Pa., successfully burned anthracite in his forge; following this demonstration it was used generally by blacksmiths throughout the Wyoming Valley.3/ In 1808 Judge Jesse Fell of Wilkes-Barre first burned anthracite in an open grate.

Anthracite was first transported to market in "arks" that moved along the rivers and canals. Many of the boats were wrecked, and their cargoes dropped to the bottom of the river. Some of the coal dredged 100 years later probably fell into the rivers in this manner.

From 1807 to 1820, inclusive, about 12,000 net tons of anthracite were produced, mostly lump size, and was used in forges and steamboats and to some extent for smelting. Only a few years later anthracite was the chief fuel employed in smelting. Production increased rapidly and in 1837 passed the million-ton mark, the output amounting to 1,071,151 net tons, whereas in the same year only 132,500 net tons of bituminous coal were mined. In 1890 the anthracite output, including fresh-mined, culm-bank, and dredge coal, was 46,468,641 net tons and rose to the all-time high of 99,511,811 tons in the war year of 1917. From 1807 to 1940, inclusive, total output was 4,385,429,000 tons.

The river-coal industry was born as the result of the mining and preparation for market of this vast amount of anthracite. Millions of tons of refuse and small-size anthracite were piled in culm banks throughout the anthracite region, and much of it found its way into watercourses; as explained in other parts of this report, the water acted as nature's agent in separating the refuse from the coal that is dredged from the rivers today.

Early Preparation Methods and Sizes Produced

To show more clearly how anthracite came into the rivers and creeks, it is well to give a short resume of the early methods of cleaning and preparing the product for market.

In the early days of anthracite mining, the coal was sold as run-of-mine, but it was not long before the producers realized that the coal was better-received by the public when it was sized and the small coal taken out. Run-of-mine was passed over a heavy grille, where extra-large pieces were broken by a man with a sledge hammer; anything smaller than stove size was not considered marketable and was piled in banks outside the mine. In some instances rakes were used to recover the larger sizes of coal

3/ The Hudson Coal Co., The Story of Anthracite: New York, N. Y., 1932, p. 24.

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inside the mine, and the smaller material was left in the gob. With the advent of breakers and shaking screens, the coal was sized more systematically and passed along chutes, from which boys and young men picked out the slate and refuse. With the market demanding only the larger sizes, and with the preparation methods in use at that time, it is evident that the culm and waste banks contained millions of tons of good coal, part of which was washed into the streams crossing the anthracite region. In the 1880's many producers were using the material from the culm banks in their boilers for steam-raising. The banks contained so much good coal that it was not always necessary to clean it before firing.

The jigging or wet method of cleaning anthracite for market was introduced in the 1870's, but it was a number of years before it spread throughout the region. The water used in wet-cleaning carried off large quantities of the smaller-size coal to creeks and rivers. In time, more efficient ways of using water to clean the coal were devised and are in use today. There is no resemblance between the quantity of culm discharged in the waste water now and that of 50 or even 25 years ago. Modern settling tanks take out even the very fine coal, and what is not used is, in many instances, stored for the future.

With improved methods of preparation and modern burning equipment came also the demand for smaller sizes. Steam-power plants found that the smallest Buckwheats could be used efficiently, and today automatic stokers in homes and industrial plants are burning Buckwheat coals.

Statistics of production by sizes before 1890 are not available for the entire anthracite region. Tables 1 and 2 show that in 1879 less than 1 percent of coal smaller than Pea size was prepared for market. From this it can be seen that large quantities of the smaller sizes could not be marketed and were piled in culm banks or were discharged into the drainage channels. As shown in tables 1, 2, and 3, recovery of small sizes and decline in percentage of Lump, Steamer, and Broken coal were underway in 1889.

Table 4 gives statistics of sizes for the entire anthracite region from 1890 to 1940. The definite trend from larger to smaller sizes is evident. Lump and broken coal, which in 1890 constituted 25 percent of the total shipments, were negligible in 1940, representing only 0.3 percent of the total product, whereas Buckwheat No. 1 and smaller, comprising 10 percent of the shipments in 1890, amounted to 36 percent of the shipments in 1940. It is apparent from these tables that sizes considered unmarketable years ago are now treated as valuable and comprise a large percentage of the anthracite shipped.

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TABLE 1. - Sizes of anthracite made by a producer in the Lehigh region, 1879 and 1889, percent[1/]

Sizes	1879	1889
Lump and Steamer	15.8	8.91
Broken	19.4	16.69
Egg	15.9	13.13
Stove	15.8	13.35
Chestnut	17.4	15.58
Pea	15.2	14.27
Buckwheat and small coals	.5	18.07

1/ Source of information : Mineral Resources of the United States, 1889-90.

TABLE 2. - Sizes of anthracite made by a producer in the Wyoming region, 1879 and 1889, percent[1/]

Sizes	1879	1889
Lump and Steamer	11.13	11.00
Broken	16.11	11.00
Egg	14.06	15.00
Stove	30.64	25.00
Chestnut	20.32	21.00
Pea	7.47	9.00
Buckwheat and small	.27	8.00

1/ See footnote 1, table 1.

TABLE 3. - Sizes of anthracite produced in the Schuylkill region, 1883 and 1889, percent[1/]

Sizes	1883	1889
Lump and Steamer	14.3	9.4
Broken	14.7	14.5
Egg	15.5	13.6
Stove	19.0	14.8
Small Stove	5.1	8.4
Chestnut	11.6	12.8
Pea	14.8	18.3
Buckwheat	5.0	8.2

1/ See footnote 1, table 1.

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TABLE 4. - Shipments of anthracite, by sizes[1/]
(Does not include Sullivan County or dredge production; washery product is included)

Sizes	1890		1901		1910	
	Net tons	Percent	Net tons	Percent	Net tons	Percent
Lump	4,825,276	11.8	2,450,059	4.1	809,499	1.1
Broken	5,216,032	12.7	4,954,414	8.3	3,745,904	5.1
Egg	5,246,274	12.8	7,828,050	13.1	8,844,518	12.1
Stove	9,345,896	22.8	11,829,392	19.7	13,404,003	18.4
Chestnut	6,899,761	16.8	11,480,616	19.1	15,964,918	21.9
Pea	5,268,246	12.8	8,462,662	14.1	8,716,780	11.9
Buckwheat No. 1	3,303,543	8.1	8,841,966	14.7	10,600,271	14.5
Smaller than Buckwheat No. 1	904,286	2.2	4,149,674	6.9	10,931,244	15.0
Total	41,009,314	100.0	59,996,833	100.0	73,017,137	100.0

Sizes	1920		1930		1940	
	Net tons	Percent	Net tons	Percent	Net tons	Percent
Lump	37,323	0.1	290,843	0.5	127,966	0.3
Broken	3,676,531	4.8				
Egg	11,092,039	14.6	6,305,322	10.4	1,963,954	4.3
Stove	13,800,437	18.2	15,418,753	25.4	10,533,860	23.1
Chestnut	19,310,694	25.4	15,463,954	25.4	11,490,689	25.2
Pea	6,051,116	8.0	4,992,326	8.2	4,947,184	10.9
Buckwheat No. 1	10,254,003	13.5	8,566,726	14.1	6,727,098	14.8
Smaller than Buckwheat No. 1	11,706,173	15.4	9,752,646	16.0	9,742,639	21.4
Total	75,928,316	100.0	60,790,570	100.0	45,533,390	100.0

1/ Source of information: Mineral Resources of the United States and Minerals Yearbooks.

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EARLY RIVER-COAL OPERATIONS

The first commercial operations to recover river anthracite were started in the Susquehanna River in the 1890's, when sand and gravel producers working the Susquehanna recovered coal as a byproduct.[4/] It is quite likely that private individuals living along the rivers and creeks recovered by hand some of the large sizes, such as Chestnut and Pea, before 1890 for use in their homes.

In the early days of the river-coal industry, heating and power plants were not equipped, as they are today, to burn the fine coal taken from the streams, and there was little demand for the product. When it became known that the dredged product could be used advantageously river coal became more popular, and in 1909 operators reported to the Geological Survey an output of 107,788 net tons, whereas in 1940 the producers of river coal reported to the Bureau of Mines 942,944 tons so obtained.

NATURE SEPARATES COAL FROM WASTE

A process by which coal was separated from rock, slate, sand, gravel, and mud was going on in the rivers and creeks that had drained the anthracite region long before somewhat similar principles were discovered and used by the growing anthracite industry to prepare coal for market at the breakers. Much of the breaker output today is prepared by making use of the principle that if coal, rock, and slate are placed in an agitated mixture of sand and water having a specific gravity slightly greater than coal but less than that of rock or slate, the coal will float to the top and the rock and slate will sink to the bottom. A somewhat similar action takes place on the culm and fine waste washed into the rivers and creeks. Being lighter, the coal moves downstream as it is buoyed by the water, whereas the slate rock and bone, with greater density, sink to the bottom farther upstream. The finer pieces of coal may become suspended in the water and be carried many miles downstream from the larger pieces. It is because of this principle that larger pieces of coal are recovered in the rivers and creeks nearer the fields than in the same streams some distance from the anthracite region.

Where the current is retarded, the coal is deposited on the river bed; this may occur in an eddy near shore, or it may be in the middle of the river where the current is sluggish because of islands or rocks in the stream. Flood waters carrying ice and debris stir the material in the

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4/ Sisler, James D., Fraser, Thomas, Ashmead, Dever C., Anthracite, Culm, and Silt: Pennsylvania Geol. Survey, Harrisburg, Pa., 4th ser. Bull. M-12, 1928, p. 168.

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upper part of rivers and creeks near the coal fields, and the coal is carried farther downstream. Coal bars in the stream may be moved quickly by the swift water caused by melting snows and rain. Many of the rivermen find dredging best in the spring and summer after flood water has carried fresh supplies of coal downstream and deposited them at a favorite dredging place.

In some sections in the vicinity of Harrisburg rocks make rough lines across the river, an ideal condition for separating the heavier material from the coal. As the water is buffeted among and over the rocks, the heavier particles drop to the bottom, and the lighter coal floats on and is deposited in pockets where the current becomes sluggish. A somewhat similar principle is employed on concentrating tables in the region proper, where the heavier waste particles are caught in the grooves on the table and the coal passes over the side with the water. The coal may accumulate to a depth of 8 or 10 feet in a river pocket such as described.

RIVERS AND STREAMS

The three principal rivers draining the anthracite regions, along which river-coal operations are conducted, are the Susquehanna, Lehigh, and Schuylkill. The Susquehanna is the largest and, with its tributaries, furnishes the greatest part of the anthracite dredged from the streams. Figure 1 shows the anthracite fields and gives a general picture of the rivers and creeks that traverse them.

Susquehanna River and Tributaries

The Susquehanna is the largest river draining the anthracite regions and with its tributaries has been the chief source of "river" coal since at least 1923, the first year for which statistics are available by individual rivers. The Susquehanna is wide and deep, with clear water, and gives little indication of the coal and mine water it has been carrying away for years. When the stream is low, river coal can be seen on some islands in the river or along sections of the shore, but it has done little to mar the beauty of the water course. The entire Northern field, extending from Forest City to Shickshinny, and parts of the Western Middle, Eastern Middle, and Southern fields are drained by the Susquehanna and its tributaries.

The Susquehanna enters the Northern field near Pittston, flows past Wilkes-Barre, Kingston, Plymouth, and Nanticoke, and leaves the field at its extreme southern tip, near Shickshinny. The total distance from Pittston to Shickshinny is only about 25 miles, but it is the most productive section

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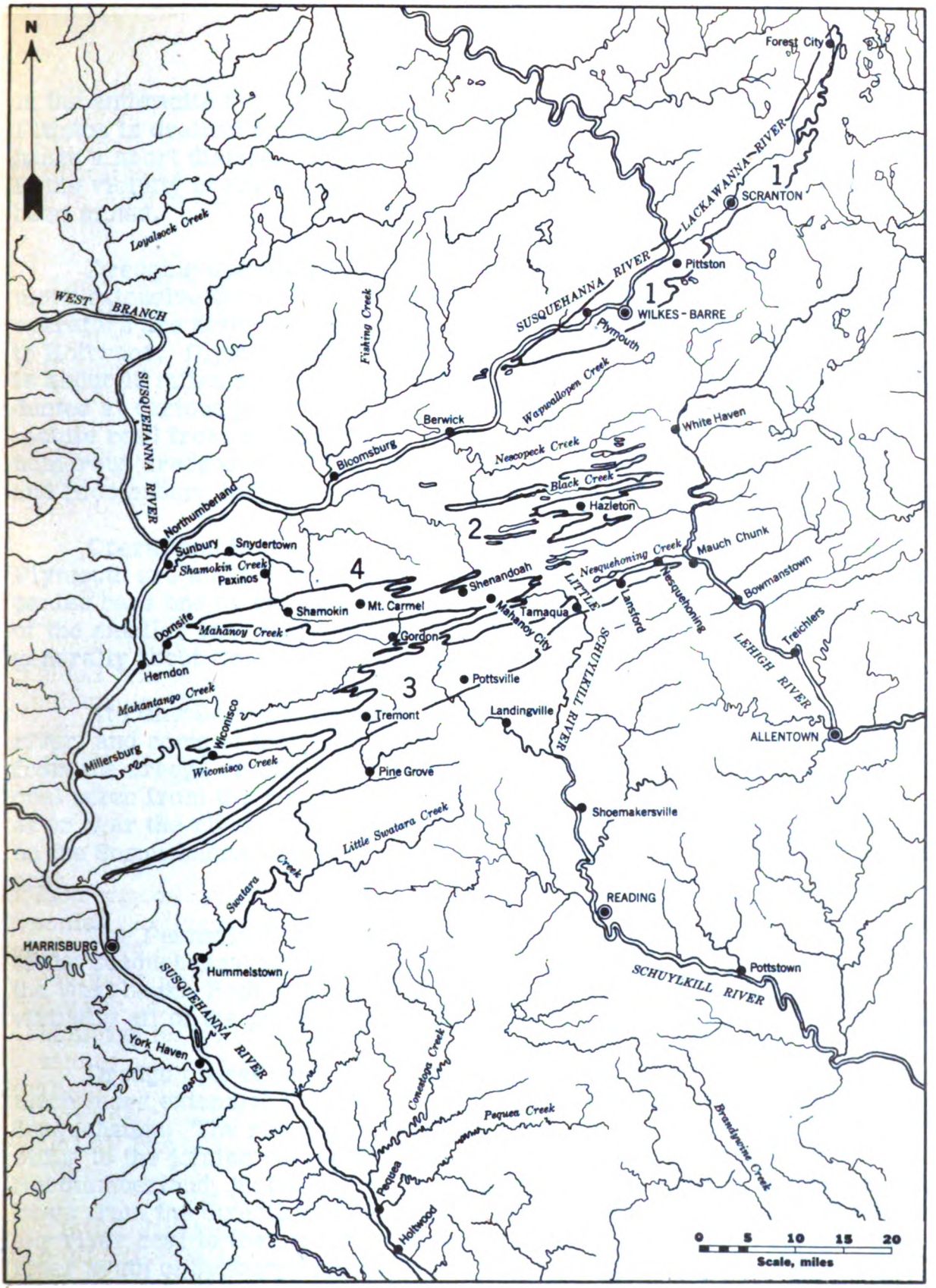

Figure 1.—Anthracite fields of Pennsylvania showing drainage by principal rivers and creeks: 1, Northern field; 2, Eastern Middle field; 3, Southern field; 4, Western Middle field.

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in the anthracite regions. That part of the Northern field north of Pittston is drained by the Lackawanna River, which enters the Susquehanna a short distance above Pittston. The Lackawanna drains an area in the vicinity of Scranton from which vast amounts of anthracite have been mined.

Dredging operations for river coal along the Susquehanna are much more extensive than those on any other river or creek. The river-coal operators are active along the stream from Plymouth, near Wilkes-Barre, to Holtwood. Plymouth is 115 miles north of Harrisburg, while Holtwood is about 45 miles south of Harrisburg, and dredging operations are conducted at various points along this entire distance (160 miles). The automobile road from Harrisburg to Wilkes-Barre follows the river, in which numerous dredges and "pushers" can be seen operating. Near Danville and Bloomsburg large piles of river coal are visible on the banks.

Operations in the North Branch of the Susquehanna from Sunbury to Plymouth are not so large as those south of Sunbury. Most of the companies have one or two dredges with a suction pump on each, while some of the smaller ones take the coal out by hand. The size recovered is generally about No. 4 Buckwheat.

At Danville and Bloomsburg operators work on both sides of the river, and some of the plants have long conveyor lines that take the coal from the dredge or flatboat to the storage piles on shore. Much of the coal taken from the river bed is used to heat State and local institutions at or near the river. Very little dredging is being done north of Espy on the Susquehanna, although that section of the river undoubtedly contains coal.

The Pennsylvania Railroad follows the east bank of the North Branch of the Susquehanna, whereas the Delaware, Lackawanna & Western follows the west bank. Both of these railroads offer good shipping facilities, but virtually all of the product dredged north of Sunbury is transported by truck.

Dredge operations south of Sunbury to Harrisburg and Holtwood are much more extensive than those conducted in the North Branch of the Susquehanna. The river is wider, and the volume of water is greater owing to the joining of the North Branch with the West Branch at Northumberland, just a few miles north of Sunbury. The West Branch flows from the direction of Williamsport, Pa., and while it does not add any river coal to the stream, it does increase the size of the river. The river south of Sunbury facilitates the formation of coal bars, and many are in evidence. Dredge-coal operators are favored, also, by creeks from

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the Eastern Middle, Western Middle, and Southern fields that flow into the Susquehanna and bring additional coal.

Principal operations along the Susquehanna south of Sunbury are conducted near Millersburg, Clarks Ferry, Harrisburg, Middleton, Pequa, and Holtwood. Permanent unloading platforms have been built near these points, and "pushers" driving flats loaded with coal ply back and forth between these stations and various points on the river where the dredges are withdrawing the coal from the stream bottom. At some points the river is about 1 mile wide, and coal is dredged from eddies on one side and transported to the unloading wharf on the other. Figure 2 illustrates transportation of coal across rivers.

Railroad shipping facilities are good along the river, but almost all of the coal is taken by truck from the unloading wharf to storage piles at the plant where it is to be used.

The two principal creeks in the Western Middle field and flowing into the Susquehanna are the Shamokin and Mahanoy. This field is the scene of steep-pitch mining, and immense amounts of refuse have been brought to the surface. Large culm banks lie alongside or near the creeks and to some extent are washed into them by the rains; the fine coal is deposited in the stream or finds its way to the Susquehanna.

Shamokin Creek with its tributaries drains an area in the vicinity of Mount Carmel and Shamokin and flows into the Susquehanna near Sunbury. There are a number of flood plains along the course where the creek widens, on which thousands of tons of silt have been deposited. Some of the largest coal-dredging operations in the anthracite region are along this creek near Paxinos and Snydertown. The silt is pumped or taken by clamshell buckets direct from the creek and is cleaned in the preparation plant on shore. (Figure 3 shows pipe in a creek through which coal passes to the cleaning plant.) Large storage piles are to be found alongside many of the plants on Shamokin Creek. Most of the dredge coal recovered from this stream is shipped by railroad, a good part of it to distant points in other States.

Mahanoy Creek, with its tributaries, drains a section of the Western Middle field in which a considerable quantity of that field's output is obtained. As in the case of Shamokin Creek, quantities of fine materials are washed from the culm banks into the creek and are then deposited along the flood plains or in other places where the current is slow. Much of the finer coal is carried on to the Susquehanna. Some of the most productive dredging operations in the Pennsylvania anthracite region are

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Figure 2.—Flatboat loaded with coal being guided to shore by pusher.

Figure 3.—Pipe in creek through which coal is drawn to plant on shore.

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conducted near Trevorton and Dornsife. At most of these the coal is pumped directly from the creek to the preparation plant, where it is cleaned on concentrating tables. Railroad facilities are good, and most of the prepared product is shipped to distant markets. Mahanoy Creek runs into the Susquehanna between Fishers Ferry and Herndon and is another source of river coal to operators working the Susquehanna River near Harrisburg and farther south.

Wiconisco Creek rises in the vicinity of Tower City and drains a section of the lower end of the Southern field. The creek flows by Williamstown and Lykens and enters the Susquehanna at Millersburg, above Harrisburg. The Wiconisco has taken away large amounts of silt and deposited it along the flood plains or carried the material to the Susquehanna.

Swatara Creek drains a large part of the Southern field around Tremont and Llewellyn and flows into the Susquehanna near Royalton, below Harrisburg. The Swatara has carried away considerable quantities of culm from refuse banks along its course. Most of the material is deposited before the creek flows into the Susquehanna; and in the vicinity of Hummelstown and Union Deposit, where the water moves slowly silt can be seen along the shores.

Both Swatara and the Wiconisco Creeks contain large quantities of silt, but operations along them are not nearly as extensive as on Shamokin and Mahanoy Creeks.

Lehigh River

The silt in the Lehigh River comes from a number of small creeks that drain the Eastern Middle field near Hazleton and from the Nesquehoning Creek, which drains a small part of the Southern field. Nesquehoning Creek flows by the town of that name and enters the Lehigh a few miles above Mauch Chunk. Quantities of silt may be seen along the course of the creek where it widens.

Operations along the Lehigh are not extensive and are conducted principally near Bowmanstown and Treichlers. Concentrating tables in plants on shore generally are used to remove fine impurities from the dredged product. Railroad shipping facilities are good along either the Central Railroad of New Jersey or the Lehigh Valley Railroad, and most of the coal is carried by railroad or is floated down the river directly to the plant where it is to be used.

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Schuylkill River

The Schuylkill River and its tributaries drain a large area of the Southern field in the vicinity of Pottsville and Tamaqua. Virtually all of the dredging is done between Reading and Pottsville. Operations are not nearly as extensive as on the Susquehanna, which is a much wider and deeper river. Most of the coal is taken from the river by rotary pumps and is prepared for market on concentrating tables in plants along the shore.

Transportation facilities are good, and the coal may be shipped to market by rail or hauled by truck. Some of the Schuylkill tonnage is used locally, while a portion is shipped to other States.

LOCATION OF DEPOSITS

Many of the old rivermen can tell by the curve of a shore line and the speed of the current where a deposit is to be found. When the shore forms an eddy and the current slows, conditions favor the deposition of coal. In the vicinity of Harrisburg the water flows swiftly among the rocks in the river and then comes into clear spaces, where the speed of the stream is slower and the coal is likely to be deposited in pockets offshore. Experienced dredgers can tell by observation the best places to establish operations. Plant sites must be chosen most carefully because many of the plants are stationary on shore and the recovery apparatus is not moved about, as in rivers; the current must not be too swift or the creek too narrow at the chosen place. Points must be selected that are near railroad or truck transportation, also, depending on whether the product is to be disposed of locally or shipped out. The current is sluggish where dams have been constructed in rivers and creeks, and many producers operate to advantage at such points.

On the Susquehanna a boat may move up and down the river and from side to side looking for pockets of coal. A man on the boat pushes a long pole or stick into the river bed and can locate coal with it. When he finds such a deposit he tests it for area and thickness and can estimate roughly in this way the tonnage it contains. Preparations are then made to recover the coal. It may be necessary to build a platform on the shore, to which flatboats loaded with coal dredged from the river are taken; and a road leading from the main highway may have to be built for trucks used to transport the coal to its destination.

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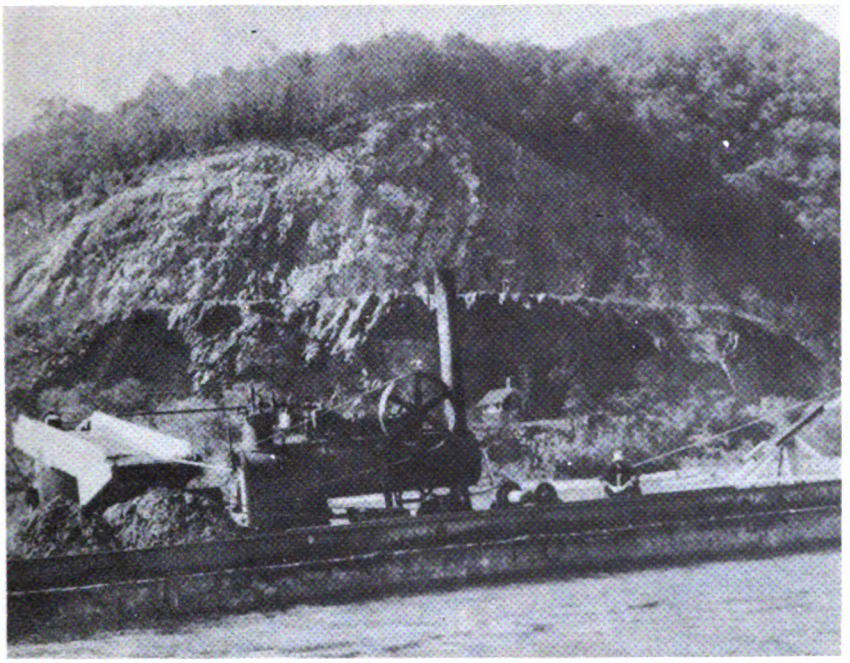

Figure 4.—Dredge, showing steam boiler and screen over which coal passes.

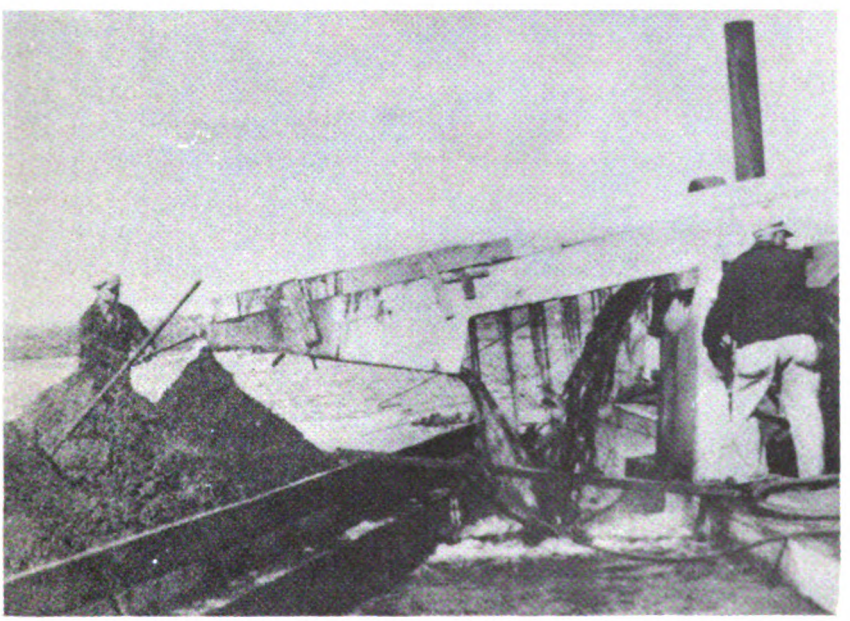

Figure 5.—Coal passing from screen on dredge to flatboat.

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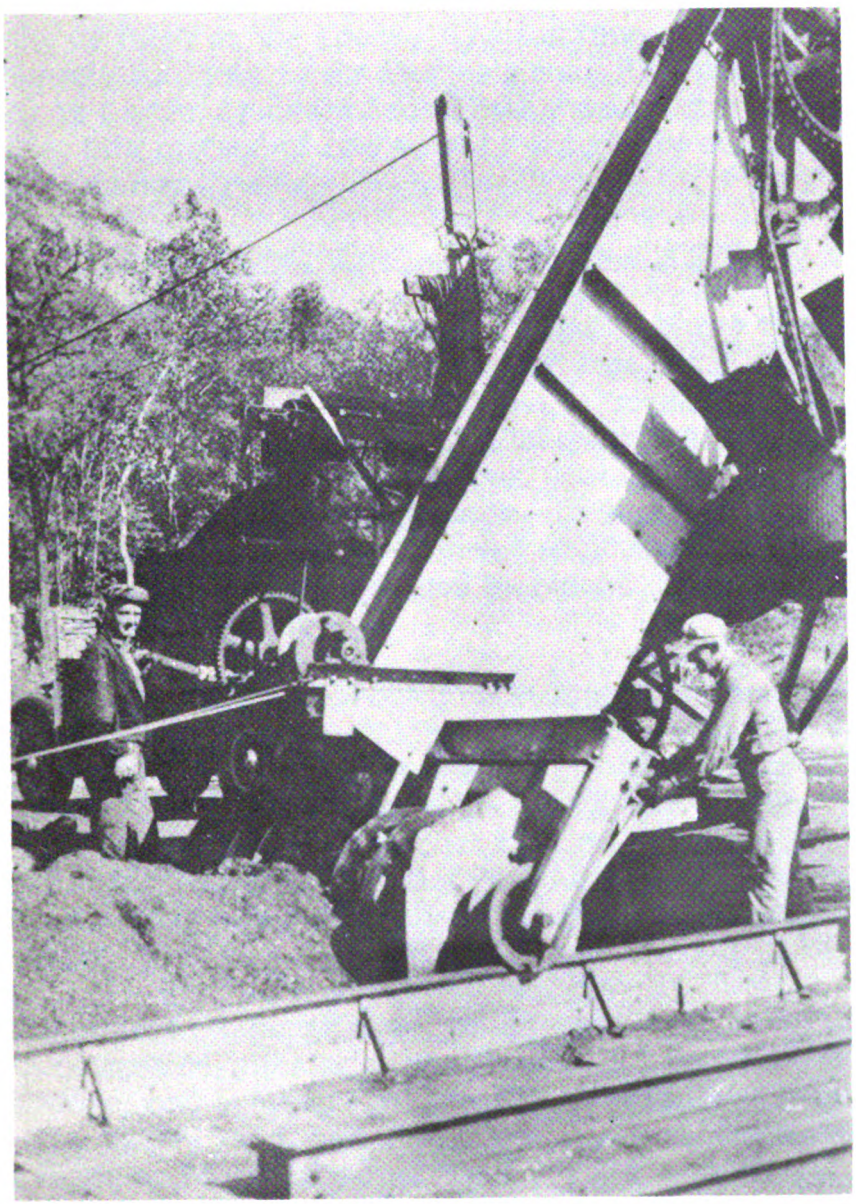

Figure 6.—Unloading coal from flatboat to truck.

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METHODS OF RECOVERY

Several methods are used to take the coal from the streams. Many are original and reflect credit on the initiative and ingenuity of the originators; however, the commonest method and that by which most of the coal is recovered is to use a centrifugal pump and suction line mounted on a floating dredge or fixed on the shore. The floating-dredge type generally is used on rivers, particularly the Susquehanna. The fixed or stationary pump is used, as a rule, on creeks too shallow and narrow to permit a floating dredge; this method of recovery is especially common on the Shamokin and Mahanoy Creeks.

Recovery Operations on the Susquehanna

The typical dredge boat is generally a flat or barge type, on which are mounted a centrifugal pump with an intake pipe, usually about 6 inches in diameter, a small steam boiler and engine to furnish power, and a set of screens over which the discharge from the pump passes. (See fig. 4.) The body of the dredge is about 40 feet long, 10 to 12 feet wide, and about 4 feet deep. The dredge is anchored in place. Generally the dredge has no motive power of its own and must be moved about by a towboat or "pusher". In the working area the dredge is moved by means of winches, to which the anchor is connected by ropes.

The towboat or pusher is about 30 feet long and 8 feet wide and is driven by a small steam engine, which supplies power to turn wood paddle wheels at the stern of the boat. It is used to move the dredges about and to take flatboats loaded with coal from the side of the dredge to the unloading point on shore. It requires an expert boat runner to cross the river with a loaded flat, and many of the pilots on the pushers are old, experienced rivermen. The pusher also plies up and down the river in search of coal deposits.

The coal is drawn through the suction pipe by the centrifugal pump, passes over a downward-pitching screen elevated 5 or 6 feet above the floor of the dredge, and extends over the side to a flatboat lashed alongside the dredge. The water, sand, and any fine waste mixed with the coal pass through the screen and flow back into the river. A man standing at the end of the screen rakes the coal off onto the flatboat. (See fig. 5.) The flatboat is about 30 feet long and 8 feet wide and holds about 15 tons of coal; when it is loaded the towboat or pusher gets behind it and pushes it to shore.

At the wharf a screw-type conveyor takes the coal from the flatboat and deposits it in a bucket conveyor, by which it is carried to the storage pile on shore, or it is loaded directly into a truck, which takes it to its destination. Figure 6 illustrates this method of unloading.

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A large part of the coal taken out of the Susquehanna River receives no further preparation than washing and screening on the dredge. Concentrating tables are used more extensively on the creeks, and that method of preparation is explained in detail under Description of Recovery Operations Along the Creeks. The use of concentrating tables insures a cleaner product, but of course the cost of a plant on shore is considerable.

Recovery Operations Along Creeks

Operators along the creeks employ various methods to recover the coal. Suction pipes and clamshell buckets operated from a stationary plant on shore are the principal means used, although some operators have conveyor lines that extend directly into the creek, and others use scraper lines. When the suction-pipe method is used, the centrifugal pump is located in a stationary cleaning plant on shore, which generally is equipped with concentrating tables. The pipe is about 6 or 8 inches in diameter and may be 30 or 40 feet in length, depending on the width of the creek. It is suspended from a boom by cables attached to pulleys and has a flexible elbow near shore that enables the boom operator to lower the pipe into the creek and to swing it in an arc along the bed of the stream. The suction pumps on shore draw water and coal through the pipe to the preparation plant, where rewashing screens and concentrating tables remove the refuse. When clamshell buckets are used, the bucket is suspended from a derrick by means of cables, and the coal is scooped from the bottom of the stream and deposited at the preparation plant on shore.

The concentrating tables used in cleaning the coal are about 6 feet wide and 16 feet long. Across the deck in a diagonal direction are tacked wood strips about 1/4 inch wide and 1 inch apart, although these dimensions may vary from plant to plant, depending on the amount of refuse in the material to be cleaned. At the top of the table the wood strips do not extend all the way across but gradually increase in length until, near the bottom, the far side is reached. The table inclines about 1/8 inch to 1 foot in a longitudinal direction and moves with a reciprocating endwise motion. There is also a slight inclination along the short side of the table, which is adjustable. Raw coal and water are delivered from the feed box to the high side of the table, where they are distributed evenly through openings in the upper side of the table. As the coal and refuse flow with the water over the table, the coal, which is the lighter, floats over the riffles, while the refuse is caught in the parallel slots and is worked by reciprocating motion to the end of the table, where it falls off into the waste trough. The coal flows over the long side of the table and is taken by a conveyor system to the storage piles.

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Many of the river-coal operators, especially the smaller ones, do not clean the coal after it reaches shore. The only preparation it receives is in the screening process on the dredge, which removes most of the sand, gravel, and other refuse. Plants that burn this coal are adapted to it and generally have no great difficulty.

PRODUCTION

The first commercial operations to recover river coal were along the Susquehanna in the 1890's, when sand and gravel operators removed the coal as a byproduct of their business. The industry was slow to develop at first because the small sizes were not utilized extensively, and it was not until later years that equipment was developed to burn the small buckwheat coals efficiently.

River-coal statistics were published first by the Geological Survey in 1909, when the output reported by dredge-coal operators was 107,788 net tons. In 1940 production as reported to the Bureau of Mines was 942,944 tons, with a reported value of $1,096,926.. The total output reported from 1909 to 1940 to the Geological Survey and subsequently to the Bureau of Mines, was 17,624,533 net tons. Statistics for some of the early years may not have been complete, because many of the dredge operators were small and could not be reached easily by correspondence.

As shown in table 5, the first year in which statistics were reported by rivers (including tributaries) was 1923, when the total production was 956,368 net tons valued at $811,065. It is to be noted that in 1923, as in every succeeding year to date, the output from the Susquehanna River and its tributaries was far greater than that of the Lehigh or Schuylkill Rivers.

The average value per ton of the river product reached a high of $1.30 in 1918, and in 1940 it was reported to the Bureau of Mines as $1.16. These values are low, when compared with the value per ton of all Pennsylvania anthracite, which averaged $3.99 in 1940.

The average output per man per day in river-coal operations is much higher than in the anthracite industry proper. In 1940 the average per man per day produced in dredging amounted to 12.60 tons compared with 3.02 tons for the entire Pennsylvania anthracite industry.

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TABLE 5. - Quantity and value of river coal by streams, 1909-40[1/]

Year	River (including tributaries), net tons				Total value	Average value per ton
	Lehigh	Schuylkill	Susquehanna	Total		
1909	.....	.....	.....	107,788	.....	.....
1910	.....	.....	.....	102,853	.....	.....
1911	.....	.....	.....	106,005	.....	.....
1912	.....	.....	.....	96,009	.....	.....
1913	.....	.....	.....	150,064	.....	.....
1914	.....	.....	.....	115,257	.....	.....
1915	.....	.....	.....	138,421	$ 100,744	$ 0.73
1916	.....	.....	.....	160,507	110,831	.69
1917	.....	.....	.....	170,672	206,754	1.21
1918	.....	.....	.....	282,930	366,565	1.30
1919	.....	.....	.....	693,093	868,746	1.25
1920	.....	.....	.....	740,453	862,296	1.16
1921	.....	.....	.....	623,329	650,654	1.04
1922	.....	.....	.....	904,108	989,709	1.09
1923	106,092	97,254	753,022	956,368	811,065	.85
1924	80,301	74,359	670,734	825,394	681,181	.83
1925	99,614	173,639	742,455	1,015,708	929,292	.91
1926	58,544	131,654	724,566	914,764	828,398	.91
1927	85,177	127,705	758,935	971,817	794,807	.82
1928	89,304	157,449	696,648	943,401	821,530	.87
1929	87,241	133,720	495,983	716,944	626,187	.87
1930	60,219	138,236	444,836	643,291	538,268	.84
1931	33,014	90,855	334,881	458,750	379,682	.83
1932	42,091	105,990	331,969	480,050	445,799	.93
1933	51,083	106,004	381,837	538,924	452,153	.84
1934	91,346	100,873	459,961	652,180	636,038	.98
1935	78,578	73,326	438,563	590,467	517,304	.88
1936	63,327	31,669	451,688	546,684	581,679	1.06
1937	95,065	2/	665,409	760,474	842,052	1.11
1938	123,452	2/	447,572	571,024	570,579	1.00
1939	62,134	67,539	574,187	703,860	746,000	1.06
1940	78,947	2/	863,997	942,944	1,097,000	1.16
Total (1923-40, inclusive)	1,385,529	1,610,272	10,237,243	3/13,233,044	12,299,014	.93

1/Source of information: Mineral Resources of the United States and Minerals Yearbooks. Data for years before 1923 not available by rivers. 2/ Included in Lehigh. 3/ Tonnage

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According to Geological Survey records of the total shipments of river coal in 1920, Buckwheat No. 3 and larger comprised 59.5 percent, whereas Buckwheat No. 4 and smaller represented 40.5 percent. In 1940 Buckwheat No. 3 and larger decreased to 46.3 percent of the shipped coal, and Buckwheat No. 4 and smaller increased to 53.7 percent. Old rivermen say that the coal recovered today is smaller than that obtained earlier, but this is compensated by greater utilization of fine coal by industrial and utility plants.

Appendix A is a directory of operators who have given the Bureau permission to publish their names as producers of river coal. In compiling the list, a letter was written to all known river and creek operators requesting authority to publish their names as producers of river coal. Some operators did not reply to this request, and there may be a few of whom the Bureau has no record. However, this group is believed to be small.

The quantity and value of river coal, as compared with fresh-mined anthracite, are not very great. However, they have increased from less than 1 percent of the fresh-mined production in 1920 to almost 2 percent in 1940. Of course, this gain in percentage can be attributed largely to the decrease in production of fresh-mined and an actual increase in output of river coal. Table 7 gives production and value of fresh-mined coal as compared with river coal from 1920 to 1940, inclusive.

QUALITY

Enough data on analyses of river coal are not at hand to permit comprehensive discussion of quality, but some general comments may be made.

The quality of river coal depends greatly on the preparation it receives after it is taken from the river. Where the coal is prepared over concentrating tables, the resulting product is clean and free from sand and gravel. Much of the river-coal output is not cleaned after initial screening and washing. It may be irregular in size and contain some sand and gravel, but it is sold upon that basis, and the price received may not be as high as for coal cleaned on concentrating tables. At some operations the river does such a good job of cleaning that the product compares favorably with table-cleaned coal. The quality depends to some extent, too, on the region in which the coal originates, as regional characteristics and differences in quality of coal from the various veins will have some effect on the quality of the river-coal product.

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TABLE 7. - Production and value of fresh-mined anthracite (including culm-bank coal) and river coal, 1920-40 1/

Year	Fresh-mined anthracite			River coal			Percentage river coal of fresh-mined production
	Production, net tons	Value	Average value per ton	Production, net tons	Value	Average value per ton	
1920	88,857,796	$ 433,389,902	$4.88	740,453	$862,296	$1.16	0.8
1921	89,850,122	451,654,249	5.03	623,329	650,654	1.04	.7
1922	53,778,914	272,710,416	5.07	904,108	989,709	1.09	1.7
1923	92,382,641	505,975,703	5.48	956,368	811,065	.85	1.0
1924	87,101,468	476,549,671	5.47	825,394	681,181	.83	.9
1925	60,801,441	326,735,220	5.37	1,015,708	929,292	.91	1.7
1926	83,522,688	473,335,854	5.67	914,764	828,398	.91	1.1
1927	79,123,747	420,146,919	5.31	971,817	794,807	.82	1.2
1928	74,404,668	392,816,160	5.28	943,401	821,530	.87	1.3
1929	73,111,251	385,016,564	5.27	716,944	626,187	.87	1.0
1930	68,741,546	354,035,923	5.15	643,291	538,268	.84	.9
1931	59,186,902	295,974,904	5.00	458,750	379,682	.83	.8
1932	49,375,171	221,929,000	4.49	480,050	446,000	.93	1.0
1933	49,002,420	206,266,000	4.21	538,924	452,000	.84	1.1
1934	56,516,111	243,516,000	4.31	652,180	636,000	.98	1.2
1935	51,568,316	209,614,000	4.06	590,467	517,000	.88	1.1
1936	54,032,851	226,422,000	4.19	546,684	582,000	1.06	1.0
1937	51,095,959	196,757,000	3.85	760,474	842,000	1.11	1.5
1938	45,528,003	180,029,167	3.95	571,024	571,000	1.00	1.3
1939	50,783,517	186,429,000	3.67	703,860	746,000	1.06	1.4
1940	50,541,696	204,393,000	4.04	942,944	1,097,000	1.16	1.9
Total	1,369,307,228	6,663,696,652	4.87	15,500,934	14,802,069	.95	1.1

1/ Source of information: Mineral resources of the United States and Minerals Yearbooks.

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The quality and size of river coal as taken from the bed of the stream depend also on the distance of the deposit from its point of origin. It has already been said that the river acts as a giant sorter, depositing larger sizes upstream and smaller sizes of equal quality much farther downstream. Likewise it is obvious that the particles of slate and rock, being heavier than coal, are deposited farther upstream than the high-grade coal. It is this principle of river sorting that creates some fine-quality coal deposits in the lower reaches of the Susquehanna.

Stream conditions may affect quality in the neighborhood of any one deposit; at flood time both coal and impurities may be deposited together; and segregation takes place later in the shifting of the deposit.

It can be stated briefly that for some deposits the river has done a remarkable job of separating coal from refuse; in these instances the anthracite as dredged is virtually equivalent to cleaned coal. In other instances the dredged product may contain some sand and gravel, and under such conditions the quality of the product depends greatly on the care with which it is prepared at the cleaning plant on shore.

USES

In the early days of the dredge industry the sizes recovered were much larger than the coal taken from the rivers and creeks today; it was large enough so that considerable quantities could be used for domestic heating. As the methods used to prepare coal at the breakers in the anthracite region improved and new markets for the small sizes were discovered, the coal finding its way into the rivers became smaller and smaller. In 1940, according to reports received by the Bureau of Mines, 83 percent of the river coal shipped was Buckwheat No. 3 or smaller. Domestic heating plants cannot burn such small coal without the help of special equipment and today, virtually all of the river coal is sold for utility or industrial purposes.

A large part of the river coal taken from the Susquehanna is used by public utilities, especially in the vicinity of Harrisburg and Holtwood. Some industrial plants along the river use the dredged product as fuel. Most of the coal taken from the Susquehanna is burned by plants on or near the river.

Considerable quantities of the coal taken from the Schuylkill and Lehigh Rivers and Mahanoy and Shamokin Creeks are employed for industrial purposes in Pennsylvania, Maryland, and Delaware, some distance from the dredging operations.

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TRANSPORTATION AND DISTRIBUTION

River coal is shipped to market by rail, truck, or barge; when destined for a distant point, it is generally shipped by rail. Large quantities of the coal dredged from Shamokin and Mahanoy Creeks and the Lehigh and Schuylkill Rivers are sent by rail to destinations in Pennsylvania, Delaware, and Maryland. Coal so shipped sometimes is loaded directly by conveyor from the concentrating tables, or it may be loaded by conveyor or clamshell buckets from storage piles at the plant and alongside the railroad.

Along rivers where unloading facilities are available, the coal is taken directly from the dredge to the plant by flatboat or barge, which reduces its cost and enables it to compete with other fuels.

When the coal is consumed only a short distance from the dredging point, the coal is often carried by truck. At small operations the coal is stored in an open place alongshore and is later loaded into the trucks by conveyor for delivery to its destination. Some of the larger operators handle the coal but once - from the flatboat by a system of conveyors to the truck that takes it to the point of consumption. Much of the coal dredged from the Susquehanna is used locally and is shipped by truck.

STORAGE OF RIVER COAL

Storage is very important to river-coal operators, and every effort is made to have several months' supply on hand. Each operator knows what his contracts require and just about what the demand will be; he also knows that the river cannot be worked at flood or when it is too low, and that most productive operations must be conducted in the spring, summer, and fall, as cold weather and ice interfere with or stop operations in winter. To retain his industrial contracts he must be able to assure purchasers of an adequate supply and to do this he must keep a well-stocked storage pile.

The storage pile may be on shore near the site of operations, or the coal may be stored at the plant where it is to be used; at some operations a supply is kept at both places. Many of the operators who store on shore take the coal directly from the dredge or flatboat to the storage pile by a system of long conveyors.

RESERVES

No attempt has been made in this study to gage the life of the river-coal industry. Hundreds of thousands of tons of culm are lying on the beds of the rivers and creeks in the Pennsylvania anthracite regions, and large

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quantities have been deposited on the banks and flood plains adjoining these streams. An extensive survey would be required to estimate the quantity of culm and silt now lying along the banks and on the flood plains that might be washed into the streams in future years. Then, too, although not as much coal is now being washed into the streams during the preparation process at the breakers as in the heyday of the anthracite industry a number of years ago, it must still be taken into consideration in estimating reserves and the life of the river-coal industry. However, it is probably safe to say that a substantial output can be expected from the river-coal industry for some years to come.

APPENDIX A. - Directory of river-coal operators dredging anthracite from streams draining the Pennsylvania anthracite regions

Operator	Address	Plant site	River or creek in which operations are conducted
Norman Bickle.....	Port Trevorton, Pa.	Independence, Pa.	Susquehanna
Central Construction & Supply Co.	2301 N. Seventh St., Harrisburg, Pa.	2301 N. Seventh St. Harrisburg, Pa.	Do.
F. H. Downey, Inc....	1329 S. Cameron St., Harrisburg, Pa.	Harrisburg, Pa.	Do.
Drifted Coal & Supply Co.....	Shoemakersville, Pa.	Shoemakersville, Pa.	Schuylkill.
Jonathan P. Edwards.	1416 Chestnut St., Philadelphia, Pa.	Hazleton, Pa.....	Hazle Creek
Fisher Coal Co.....	Orwigsburg, Pa.....	Gordon, Pa.....	Mahanoy Creek.
B. W. Fordham.....	Trevorton, Pa.....	Hunter Station, Pa.	Do.
Fred R. Fox.....	R. D. 5, Bloomsburg, Pa.	R. D. 5, Bloomsburg, Pa.	Susquehanna
A. J. and William Frymire.....	Shamokin Dam, Pa.	Shamokin Dam, Pa.	Do.
General Dredging Co.	104 W. Main St., Bloomsburg, Pa.	Espy, Pa.....	Do.
Gulliver Bros.....	Espy, Pa.....	Espy, Pa.....	Do.
Herrold Brothers.....	Port Trevorton, Pa.	Port Trevorton, Pa.	Do.
N. E. Herrold.....	Sunbury, Pa.....	Sunbury, Pa.....	Do.
Luther Hess.....	Espy, Pa.....	Espy, Pa.....	Do.
Leo Hoffman.....	R. D. 5, Bloomsburg, Pa.	Espy, Pa.....	Do.
Paul G. Hoover.....	Port Trevorton, Pa.	Port Trevorton, Pa.	Do.
Hoover Coal Mining Co.....	Y.M.C.A. Bldg., Sunbury, Pa.	Paxinos, Pa.....	Shamokin Creek
Hoover & Hoover	Selinsgrove, Pa.....	Port Trevorton, Pa.	Susquehanna

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APPENDIX A. - Directory of river-coal operators dredging anthracite from streams draining the Pennsylvania anthracite regions

Operator	Address	Plant Site	River or creek in which operations are conducted
Harvey Hottenstein	Shamokin Dam, Pa..	Shamokin Dam, Pa.	Susquehanna
Cloyd E. Houseworth	Port Trevorton, Pa.	McKees Half Falls	Do.
Housholder & Steward.....	1615 Penn St., Harrisburg, Pa.	Hummelstown, Pa.	Swatara Creek
F. O. Hummel.....	Port Trevorton, Pa.	Independence, Pa.	Susquehanna
Jonathan Coal Mining Co.	1416 Chestnut St., Philadelphia, Pa.	Dornsife, Pa.....	Mahanoy Creek
Do.	.....do.....	South Barry, Pa..	Do.
Do.	.....do.....	Deibler, Pa.....	Shamokin Creek
Do.	.....do.....	Reed Station, Pa...	Do.
Do.	.....do.....	Shamrock, Pa.....	Do.
Do.	.....do.....	Snydertown, Pa.....	Do.
J. Henry Keller.....	Port Trevorton, Pa.	Port Trevorton, Pa	Susquehanna
Landingville Coal Co.	6 Parkway, Schuylkill Haven, Pa.....	Landingville, Pa.	Schuylkill
McGready & Krout Co.	York Haven, Pa.....	Cly, Pa.....	Susquehanna
M. & A. Coal Co.....	218 E. Liberty St., Schuylkill Haven, Pa.....	South of Schuylkill Haven, Pa.	Schuylkill
C. M. Peifer.....	Dornsife, Pa.....	3 1/2 mi. east of Hunter Station, Pa.	Mahanoy Creek.
Pennsylvania Water & Power Co.....	1611 Lexington Bldg, Baltimore, Md.	Holtwood, Pa.....	Susquehanna
Pequea Fuel Co.....	304 N. Second St., Harrisburg, Pa.	Pequea, Pa.....	Do.
Reynolds Coal Co.....	218 E. Liberty St., Schuylkill Haven, Pa.....	Reynolds, Pa.....	Little Schuylkill
Eugene Schafer.....	Schuylkill Haven, Pa.....	Schuylkill Haven, Pa.....	Schuylkill.
Wm. B. Shoener.....	Adamsdale, Pa.....	Drehersville, Pa...	Little Schuylkill.
Mary W. Sickler Estate.....	387 S. River St., Wilkes-Barre, Pa.	Plymouth, Pa.....	Susquehanna
Chas. E. Spade &Sons	Dornsife, Pa.....	Dornsife, Pa.....	Mahanoy Creek
Steam Coals, Inc.....	Shamokin, Pa.....	Hunter Station, Pa.	Mahanoy Creek

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Operator	Address	Plant site	River or creek in which operations are conducted
M. B. Stewart	West Fairview, Pa.	Amity Hall, Pa.	Susquehanna
Do	.....do.....	Steelton, Pa.	Do.
Do	.....do.....	Millersburg, Pa.	Do.
Treichler Drifted Coal Co.	Shoemakersville, Pa.....	Treichlers, Pa...	Lehigh.
Raymond A. Wren...	601 W. Market St., Williamstown, Pa.	Williamstown, Pa.	Wiconisco Creek.

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